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# MONITORING AND EVALUATION STUDENTS' LEARNING ACHIEVEMENTS THROUGH THEIR LEARNING ACTIVITIES WITH THE STEM EDUCATION INSTRUCTIONAL METHOD FOR DEVELOPING THEIR CREATIVE THINKING ABILITIES AND THEIR ATTITUDES TOWARD SCIENCE OF SECONDARY STUDENTS AT THE 11TH GRADE LEVEL IN PHYSICS CLASSES

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**Abstract:**
Educational management approaches that integrate knowledge in four subjects, including science, technology, engineering, and mathematics (STEM Education Method: STEME) to develop learning achievement, attitude, and creative thinking ability toward science of secondary students at the 11th grade level in physics classes. The aims of this research study were to analyze of the processing performances and the performance results ($E_1/E_2$) efficiency at the determining criteria as 75/7, to compare students' learning achievements of their pretest and posttest assessments in cording in the STEME, to assess students' responses of their creative thinking abilities with the STEME, to assess students' perceptions of their science related attitudes with the STEME, to associated between students' post learning achievements and their creative thinking abilities the STEME, and to associated between students' post learning achievements and their science related attitudes with the STEME. The target group consisted of 72 secondary students in two physics classes from Borabu Wittayakhan

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School in the academic year of 2/2016. Using the instructional innovative lesson plans of the STEME on *Eclectic and Magnetics Issue* in 14 hours was administered, the 30-item *Learning Achievement Test* (LAT), the 24-item *Creative Thinking Ability Assessment* (CTAA); and the 8-item *Test Of Science-Related Attitude* (TOSRA) were assessed. Statistically significant was analyzed with the foundational and advance statistics. The Results of these research findings have found that: Students were evaluated to determine performance criteria with the efficiency of the processing performance and the performance results ($E_1/E_2$) of 80.32/75.77 for the STEME innovation lesson plans, which was higher than standardized criteria of 75/75. Students' learning achievements of their pretest ($\bar{\chi}$ = 15.77, S.D. = 2.24) and post-test ($\bar{\chi}$ = 19.87, S.D. = 3.26) and t-test = 20.42 were differentiated evidence at the 0.001 level, significantly. Students' responses of their critical thinking abilities for the CTAA in fluency, flexibility, originality, and elaboration abilities, respectively, as a whole indicated at the high level ($\bar{\chi}$ = 3.67, S.D. = 0.83), and the Cronbach alpha reliability = 0.87**.** Students' perceptions of their attitudes toward science with the TOSRA indicated that $\boldsymbol{\alpha}$ – reliability = 0.78, all on their average scores ranged from 3.31 to 3.90, as a whole indicated that a high level for their perceptions. Associations between students' learning achievements of their post-test assessment indicated that 59% of the coefficient predictive value ($R^2$) of the variance in students' creative thinking abilities was attributable to their perceptions for the CTAA and the relationship between students' statistical achievements at the .001 level was significantly. Students' learning outcomes of their post-test assessment, the $R^2$ value indicated that 51% of the variances in students' perceptions to their science related attitude for the TOSRA, and the relationship between students' statistical achievements at the .001 level were significantly.

**Keywords:** monitoring and evaluation, students' earning achievements, learning activities, STEM education, instructional method, creative thinking abilities, attitudes related science, physics classes

## 1. Introduction

Monitoring and evaluation (M&E) is a process that helps improve performance and achieve results. Its goal is to improve current and future management of outputs, outcomes and impact. It is mainly used to assess the performance of projects, institutions and programs set up by governments, internal organizations and NGOs. It establishes links between the past, present and future actions (United Nations

Development STEM education method Evaluation Office, 2013). Monitoring and evaluation processes can be managed by the donors financing the assessed activities, by an independent branch of the implementing organization, by the project managers or implementing team themselves and/or by a private company. The credibility and objectivity of monitoring and evaluation reports depend very much on the independence of the evaluators. Their expertise and independence is of major importance for the process to be successful. The M&E is, as its name indicates, separated into two distinguished categories: Evaluation and Monitoring. An evaluation is a systematic and objective examination concerning the relevance, effectiveness, efficiency and impact of activities in the light of specified objectives (UNICEF, 2012).

The idea in evaluating projects is to isolate errors not to repeat them and to underline and promote the successful mechanisms for current and future projects. An important goal of evaluation is to provide recommendations and lessons to the project managers and implementation teams that have worked on the projects and for the ones that will implement and work on similar projects. Monitoring is a continuous assessment that aims at providing all stakeholders with early detailed information on the progress or delay of the ongoing assessed activities (United Nations Development STEM education method Evaluation Office, 2013). It is an oversight of the activity's implementation stage. Its purpose is to determine if the outputs, deliveries and schedules planned have been reached so that action can be taken to correct the deficiencies as quickly as possible. Although evaluations are often a retrospective, their purpose is essentially forward looking. Evaluation applies the lessons and recommendations to decisions about current and future STEM education methods. Evaluations can also be used to promote new projects, get support from governments, raise funds from public or private institutions and inform the general public on the different activities (UNICEF, 2012). In this research study focused on the monitoring and evaluation students' learning achievements through their learning activities with the STEM education instructional method for developing their creative thinking abilities and their attitudes toward science of secondary students at the 11$^{th}$ grade level in physics classes.

## 2. Students' Learning Achievements

The National Board for Professional Teaching Standards by Robert Linn (2014) reports on *Student Learning, Student Achievement: How do Teachers Measure up?* The other important factor pertains to the critical distinction between student learning and student achievement. Although the two terms are often used interchangeably, they convey profoundly different ideas, particularly as they relate to teaching. In brief, student achievement is the status of subject-matter knowledge, understanding, and skills at one point in time, while student learning is the growth in subject-matter knowledge, understanding, and skills over time. It is student learning, not student achievement, that is relevant to defining and assessing accomplished teaching. In an attempt to measure student learning, many growth models have been developed. Of those models, the "value-added" approach has emerged as the method of choice to estimate the contributions that specific teachers and schools make to the growth in student learning. But while value-added models place necessary focus on important student outcomes, they remain constrained by technical issues involving the nature of tests, data quality, and the appropriate application of statistical models and methodologies.

As we explain in greater detail later, even with better assessments, there will always be challenges in determining how much each teacher contributes to student learning. Education is a complex process with many actors, including teachers, principals, tutors, reading coaches, librarians, and—perhaps most important parents. For this reason, thoughtful evaluations of teacher performance must combine direct evidence of student learning such as "value-added" data and examinations of teaching practice. Gains in student learning must always be examined within the context of teaching practice to ensure that they are connected to what teachers are doing in the classroom. To better understand the complexities surrounding measurements of student learning and their role in the evaluation of teacher effectiveness, the Student Learning, Student Achievement Task 10 Force, which includes some of the National Board's most articulate critics, was charged with: Describing how student learning and achievement are captured in the National Board's evidence-based standards and certification process; Defining the critical distinction between student achievement and student learning; Identifying traditional and alternative approaches to measuring student learning; and Evaluating the strengths and limitations of these approaches as measures of teacher effectiveness. This research study was to adapt these learning assessments for students into their learning achievements with the pretest and posttest design.

**3. Pretest-Posttest Designs for Assessing the Achievements of Learning**

A main innovative lesson plan was provided a general definition of student achievement, defined factors that impact a student's ability to achieve and explains what research shows about successful student achievement with the 6-sub lesson plans. Student achievement has become a hot topic in education today, especially with increased accountability for classroom teachers. The ultimate goal for any teacher is to improve the ability level and prepare students for adulthood. Defining student achievement and factors that impact progress is critical to becoming a successful teacher. Student achievement measures the amount of academic content a student learns in a determined amount of time. Each grade level has learning goals or instructional standards that educators are required to teach. Standards are similar to a 'to-do' list that a teacher can use to guide instruction. Student achievement will increase when quality instruction is used to teach instructional standards. Researchers want to monitor the effect of a new teaching method upon groups of students. Pretest-posttest designs were an expansion of the posttest only design with the target groups, one of the simplest methods of testing the effectiveness of an intervention. In this design, which was given the treatment and the results were gathered at the end with statistical analysis that can then determine the intervention had a significant effect.

**4. The Context of the Strand and Learning Standard in Science Learning Area**

Most schools in Thailand are ambitious in prescribing the learning areas, leading to overcrowded curriculums. Excessively high expectations were also set. Measurement and evaluation did not correlate with the standards set which effected on preparation of certifying documents and transferring of learning outcomes. Moreover, problems regarding learners' ability to acquire essential knowledge, skills, capacities and desired characteristics were quite disconcerting (Bureau of Academic Affairs and Educational Standards, 2008). Furthermore, the new curriculum; the Basic Core Curriculum B.E. 2551 (A.D. 2008) and the Basic Core Curriculum B.E. 2558 (A.D. 2015) (Draft) has prescribed a structure of minimum time to be allotted to each subject area for each grade level. Schools are given opportunities to increase learning time allotment, depending on their readiness and priorities. Improvement has been made to the process of measuring and evaluating learners' performance as well as criteria for graduation at each educational level. Adjustment has also been made for streamlining certification which correlates with learning standards, thus facilitating application of certifying documents (Ministry of Education, 2008).

From the context of this basic core curriculum problem of learning management in science classroom in physics course is integrated. The problem of achievement of learning management at source has been achieved as low. The Institute the Promotion of Teaching Science and Technology (IPST) has been trying to solve the problems of learning management model with the integration of science education, this is just the beginning. Although there are eight centers, eight centers are located in different parts of the country (Ministry of Education, 2015). The goals of this curriculum are observance of the principles of development of the brain and multiple intelligences is required to achieve learners' balanced development that has therefore prescribed the following eight learning areas: Thai Language; Mathematics; Science; Social Studies, Religion and Culture; Health and Physical Education; Art, Occupations and Technology; and Foreign Languages. In terms of the Strands and Learning Standards in Science learning core, which it contains of eight Strands and 13 Learning Standards. In this research study would be selected at the Strand 4: Forces and Motion that focused on the Standard SC4.2: Understanding of the characteristics and various types of motion of natural objects; having investigative process for seeking knowledge and scientific reasoning; transferring and putting the knowledge into practice was selected of the context of content on Electric and Magnetic Issue was selected of the context limitation of this learning activity design at this study (Ministry of Education, 2012).

## 5. Classroom Learning Activities

Learning is an active, constructive process that is contextual; new knowledge is acquired in relation to previous knowledge; information is meaningful when it is presented in some type of framework (Davis, 1993). Active learning is not a new concept. It "derives from two basic assumptions: (1) that learning is by nature an active endeavor and (2) that different people learn in different ways" (Meyers and Jones, 1993). When teachers discuss active learning in the classroom, it is with the understanding that lecture is still important – the foundational knowledge required for students to be able to engage in higher level thinking is essential. However, for the sake of maintaining student interest, and facilitating meaningful, and eventually self-directed learning, it can be very helpful to vary the teaching and learning activities teacher employ in the classroom. It is likely that teachers are already using teaching and learning techniques that help students to engage actively with the concepts teachers are teaching, and there are still more ways to expand the learning experiences teachers create – some very low risk, some more complex, but all can be effective, especially if teachers establish this pattern of interaction from the first day of their course.

Focused on the *Effective Learning Activities*, there are a wide range of activities used both inside and outside the classroom that promote active learning. While each discipline has traditional ways of teaching certain subject matter, and activities used in seminars and large lectures may vary, the concept of "active learning" applies in every discipline, in every class size. The types of activities teachers choose to use, however, might be more applicable in some types of courses than others. Some more complex forms of active learning include service learning, problem-based learning, collaborative learning (team based) and simulations. These can all be very effective, especially in upper level undergraduate and graduate courses where holistic learning is emphasized and students are encouraged to think about solving problems in "real world" situations and learning skills relevant to their field. However, there are many low risks, high benefit activities that teachers can use that require less time, and can also be very effective, as demonstrated in the list below. Some are individual in nature, some involve groups, and some might progress from individual activity to group activity. Be creative! (Center for the Enhancement of Learning & Teaching, 2010)

## 6. Instructional Design with the STEM Education

Student learning outcome performances clearly state the expected knowledge, skills, attitudes, competencies, and habits of mind that students are expected to acquire at an institution of higher education. Transparent student learning outcomes statements are; specific to institutional level and/or content level, clearly expressed and understandable by multiple audiences, prominently posted at or linked to multiple places across the other context, to be updated regularly to reflect current outcomes, and to be receptive to feedback or comments on the quality and utility of the information provided (National Institute for Learning Outcomes Assessment, 2010). STEM stands for science, technology, engineering, and mathematics. STEM is important because it pervades every part of our lives. Science is everywhere in the world around us. Technology is continuously expanding into every aspect of our lives. Engineering is the basic designs of roads and bridges, but also tackles the challenges of changing global weather and environmentally-friendly changes to our home. Mathematics is in every occupation, every activity we do in our lives. By exposing students to STEM and giving them opportunities to explore STEM-related concepts, they will develop a passion for it and hopefully pursue a job in a STEM field.

A curriculum that is STEM-based has real-life situations to help the student learn. Student integrates multiple classes to provide opportunities to see how concepts relate to life in order to hopefully spark a passion for a future career in a STEM field. STEM activities provide hands-on and minds-on lessons for the student. Making math and science both fun and interesting helps the student to do much more than just learn (National Science Foundation, 2016). In the 21st century, scientific and technological innovations have become increasingly important as we face the benefits and challenges of both globalization and a knowledge-based economy. To succeed in this new information-based and highly technological society, students need to develop their capabilities in STEM to levels much beyond what was considered acceptable in the past. In conclusion, STEM education is critical to help many countries remain the world leader. If STEM education is not improved, each country will continue to fall in world ranking with math and science scores and will not be able to maintain its global position. STEM education in school is important to spark an interest in pursuing a STEM career in students. However, teachers do not carry the whole burden of STEM education. Parents also must encourage their children to pursue STEM activities and increase awareness and interest at home and in extracurricular activities of the merits of STEM education (National Science Foundation, 2016).

## 7. Selected the STEM Education Instructional Design

To design in the instructional model for provide all the tools and strategies of this research study' plan to need to design integrated, interdisciplinary STEM lessons and units that are relevant and exciting to the target group students. With clear definitions of both STEM and STEM literacy, the authors argue that STEM in itself is not a curriculum, but rather a way of organizing and delivering instruction by weaving the four disciplines together in intentional ways. Rather than adding two new subjects to the curriculum, the engineering and technology practices can instead be blended into existing mathematics and science lessons in ways that engage students and help them master 21$^{st}$ century skills. STEM Innovative Lesson Plans of the essentials was built how to begin the STEM integration journey with: five guiding principles for effective STEM instruction, physics laboratory classroom environments were responded of what these principles look like in action of students' perceptions, sample activities that put all four

STEM fields into practice, and lesson planning templates for STEM units were assessed by the professional expert educators were checked of their efficiency quality.

### 7.1 Approach the Guilford's Work to Test of Creative Thinking Ability

Creative thinking skills are essential for success in learning and success in life (Fisher, 2006). Creative thinking skills equips students to go beyond the information given, to deal systematically, flexibly with problems and situations, to adopt a critical attitude to information and arguments as well as to communicate effectively (McGuinness, 1999). Guilford (1950) proposed creativity as the ability to produce a new idea into existence via divergent thinking or arrive at many solutions to a problem, and offered three dimensions to describe creativity: *fluency*: ability to generate lots of ideas; *flexibility*: ability to look at a question or topic from multiple perspectives; *originality*: is the crux of creativity; and *elaboration* is the ability to systematize and organize the details of an idea in a head and carry it out) were built. Creativity can also mean to generate unique or unusual and unexpected ideas. To evaluate creativity, there must be measurable indicators to determine how much students have gained from learning. The formal psychometric measurement of creativity is usually considered to have begun with Guilford (1950). Guilford's group constructed several tests to measure creativity in 1967 such as: plot titles; quick responses; figure concepts; unusual uses; remote associations; and remote consequences. In this research study, adapted and improved version of the Guilford first proposed the concept of "divergent thinking" in the 1950s, when he noticed that creative people tend to exhibit this type of thinking more than others.

### 7.2 Assessing Science-Related Attitudes

To assessing science-related attitudes along seven dimensions: social implications of science, normality of scientists, attitude toward scientific inquiry, adoption of scientific attitudes, enjoyment of science lessons, leisure interest in science, & career interest in science. Using the short version of the *Test of Science Related Attitudes* (TOSRA) (Fraser, 1981; Santiboon and Fisher, 2005) that it used to assesses science-related attitudes along seven dimensions: social implications of science, normality of scientists, attitude toward scientific inquiry, adoption of scientific attitudes, enjoyment of science lessons, leisure interest in science, & career interest in science (Fraser, 1981). Fraser developed the survey to measure seven science related attitudes among secondary school students. Fraser based his design on the early work of Klopfer (1971). In his classification system, Klopfer's first scale was called "Manifestation of favorable attitudes towards science and scientists." The TOSRA was used to associate student outcomes and the classroom-learning environment, particularly to add the measure of students' attitudes towards science and achievement. This research study references the extensive of Santiboon and Fisher's work that it was shown high reliability results for modifying version from the origin was all measured to assess changes in students' attitudes toward science and science related physics content issues, because of participating in physics classes with the instructional management between STEM education method were associated.

As above, the monitoring and evaluation was assessed students' learning achievements through their learning activities in cording to the STEM education instructional method for developing their creative thinking abilities, which it was adapted from Gildford' framework and their attitudes toward science that modified from the short version of the 8-item *Attitude Scale* of Santiboon and Fisher (2005) to assess science-related attitudes along seven dimensions: social implications of science, normality of scientists, attitude toward scientific inquiry, adoption of scientific attitudes, enjoyment of science lessons, leisure interest in science, & career interest in science Fraser, 1981) of secondary students at the 11th grade level in physics classes in this research study.

## 8. Methodology

The process by which instruction is improved through the analysis of learning needs and systematic development of learning experiences; the instructional designers often use technology and multimedia as tools to enhance instruction. It is designed to provide information about *instructional design* principles and how they relate to teaching and learning. Instructional design (or instructional systems design), is the analysis of learning needs and systematic development of instruction. Effective instructional designers are also familiar with a wide range of educational technology that can be used for delivering learning experiences. Instructional design models provide a method, that if followed will facilitate the transfer of knowledge, skills and attitude to the learner. Presenting content in a simple, meaningful way is the art of good instructional design. Researcher team was increasingly seeing an emphasis on STEM integration in upper secondary school classrooms such that students would learn and apply relevant math and science content while simultaneously developing engineering habits of mind. However, research in both science education and engineering education suggests that this goal of truly integrating the STEM is rife with challenges. To compare between students' learning achievements were assessed, students' performances of their critical thinking abilities and their attitudes towards science were associated. The research methodology was following as:

### 8.1 Research Aims

1. To analyze of the processing performances and the performance results ($E_1/E_2$) efficiency at the determining criteria as 75/7.
2. To compare students' learning achievements of their pretest and posttest assessments in cording in the STEME method.
3. To assess students' responses of their creative thinking abilities with the STEME method.
4. To assess students' perceptions of their science related attitudes with the STEME method.
5. To associated between students' post learning achievements and their creative thinking abilities the STEME method.
6. To associated between students' post learning achievements and their science related attitudes with the STEME method.

### 8.2 Research Procedures

**Step I: Designing the Instructional Learning Plan**

The instructional learning plan, the STEM Education Method on Different Types of Motion Issue of secondary students at the 10$^{th}$ grade level in physics classes that followed as the content of physics in the Strand SC 4 of the Basic Education Core Curriculum 2008 and 2015 (Draft) were selected. Defining the nature and format of the innovative learning management plans composed of Name, Title, Title, Subject, Class, and Time; Learning Standards, Essence, Learning Objectives, Learning Management Process, STEM Education Method Processes, Media/Learning Resources, Evaluation, and Scientific Process Skills were designed in 15 hours for instructional and evaluating learning outcomes of students' learning activities in the first step of research procedure.

**Step II: Creating the Pretest-Posttest Designs**

A main innovative lesson plan was provided a general definition of student achievement, defined factors that impact a student's ability to achieve and explains what research shows about successful student achievement with the 6-sub lesson plans. Student achievement will increase when quality instruction is used to teach instructional standards. Researchers want to monitor the effect of a new teaching method upon groups of students. Pretest-posttest designs were an expansion of the posttest only design with the target groups, one of the simplest methods of testing the effectiveness of an intervention. In this design, which was given the treatment and the results were gathered at the end with statistical analysis that can then determine the intervention had a significant effect. The 30-item *Leaning Achievement Test* (LAT) on Electric and Magnetic Issue was created by the researcher team of 40 optional items in 4 multiple choice options was assessed in the second step of research procedure.

**Step III: Using the STEM Education Method in 21st-Century**

Exactly, with clear definitions of both STEM education and STEM literacy, the authors argue that STEM in itself is not a curriculum, but rather a way of organizing and delivering instruction by weaving the four disciplines together in intentional ways. Rather than adding two new subjects to the curriculum, the engineering and technology practices can instead be blended into existing mathematics and science lessons in ways that engage students and help them master 21st century skills. STEM Innovative Lesson Plans of the essentials was built how to begin the STEM integration journey with: five guiding principles for effective STEM instruction, physics classes were responded of what these principles look like in action of students' perceptions, sample activities that put all four STEM fields into practice, and lesson planning templates for STEM units were assessed by the professional expert educators were checked of their efficiency quality in the third step of research procedure.

**Step IV: Adapted the Creative Thinking Abilities**

Using the original version of the original of the Guilford's intelligence work; the *Guilford Divergent Thinking Questionnaire* was adapted to assess students' perceptions of their creative thinking abilities with the 24-item *Creative Thinking Ability Test* (CTAT) in 4 scales, namely *Fluency Thinking* (the ability to produce great number of ideas or problem solutions in a short period of time); *Flexibility Thinking* (the ability to simultaneously propose a variety of approaches to a specific problem); *Originality Thinking* (the ability to produce new, original ideas); *Elaboration Thinking* (the ability to systematize and organize the details of an idea in a head and carry it out).

**Step V: Selected the Test of Science-Related Attitudes (TOSRA)**

The original of the *Test of Science-Related Attitudes* (TOSRA) was assessed science-related attitudes along seven dimensions: social implications of science, normality of scientists, attitude toward scientific inquiry, adoption of scientific attitudes, enjoyment of science lessons, leisure interest in science, & career interest in science and obtained of 70 items (Fraser, 1981). The term "attitude" is very common and popular in daily life. Everyone has given it its own meanings, concepts and definitions. An aim of this study was to explore the psychometric attitudes of the *Test of Science-Related Attitude* (TOSRA) to adapt to the Thai version that it obtained of 21 items (Santiboon and Fisher, 2005) was assessed students' perceptions of their attitudes toward science in physics classes in the five step of research procedure.

### 8.3 Sample Target

The sample target was the upper secondary educational school students who sat at the $10^{th}$ grade level, which consisted of 72 students in two physics classes in the second semester of academic year 2016 at Burabu Wittayakhan School under the Secondary Educational Service Area Office 26 in Maha Sarakham Province with the purposive sampling technique.

### 8.4 Data Analysis

Using the foundational statistic with percentage, mean, standard deviation for analyzing the basically data was examined. The validity and reliability of research instruments were assessed with internal consistency Cronbach alpha reliability and discriminant validity. Statistically significant was differentiated data to compare with the independent variable t-test and ANOVA results ($eta^2$). Associations between students' learning achievements of their posttest outcomes and their creative thinking abilities to their perceptions toward their physics laboratory classroom environments with simple and multiple correlations, standardized regression weight abilities and the coefficient predictive value ($R^2$) were analyzed.

## 9. Results

The monitoring and evaluation students' learning achievements through their learning activities with the STEM education instructional method for developing their creative thinking abilities and their attitudes toward science of secondary students at the $11^{th}$ grade level in physics classes to analyze of the processing performances and the performance results ($E_1/E_2$) efficiency at the determining criteria as 75/75, to compare students' learning achievements of their pretest and posttest assessments, to assess students' responses of their creative thinking abilities, to assess students' perceptions of their science related attitudes, to associated between students' post learning achievements and their creative thinking abilities, and to associated between students' post learning achievements and their science related attitudes with the STEME method. The results of these research findings have followed as:

### 9.1 Validations and Reliabilities of the Research Instruments

#### A. The IOC Value of the STEM Education Innovative Instructional Lesson Plan

The STEM education innovative instructional lesson plan was created learning plan offers the counselor to verify the content validity for students' learning activities, teaching materials, and evaluation in the learning management plan was corrected as suggested by the advisors and the 3-professional expert educators with the were reviewed and assessed the validity of content, purpose learning with the IOC value (*Index of Item Objective Congruence*), the acceptable accuracy must be 4.47 or higher. It appears that the research plan developed by the researcher has an average of 3.51 to 5.00, which is moderate to the highest.

#### B. Validations of the Leaning Achievement Test (LAT)

The 30-item *Leaning Achievement Test* (LAT) on Electric and Magnetic Issue was created by the researcher team of 30 optional items in 4 multiple choice options was assessed in the second step of research methodology. The LAT was used to analyze the difficulty, the discriminative value of the achievement test using the criterion-selection criteria was 0.80 – 1.00 and the discriminative value ranged from 0.22 to 0.69.

#### C. Validations of the Critical Thinking Ability Test (CTAT)

Using the 24-item *Critical Thinking Ability Test* (CTAT) that it has 6 optional components in 4 multiple choice options was assessed students' critical thinking abilities were assessed with the CTAT. The quality of the critical thinking ability test was then analyzed by qualitative (p), discriminative value (r), and confidence using the KR-20 formula. The CTAT was indicated that of the difficulty (p) ranged from 0.21 to 0.79, with the discriminative value (r) between 0.34-0.65 and the internal consistency (Cronbach rerilabiliy) was 0.85.

#### D. Validations of the Test of Science-Related Attitudes (TOSRA)

The *Test of Science-Related Attitudes* (TOSRA) questionnaire was selected to use with the aim of investigating any possible relationships with the instructional management between STEM education methods for developing students' attitudes toward science. The TOSRA consists of eight items and the five response alternatives are: *Almost Never* (1), *Seldom* (2), *Sometimes* (3), *Often* (4) and *Very Often* (5). The minimum score as 8 and maximum score as 40, and the average mean score range from 1.00 to 5.00 was indicated. The internal consistency (Cronbach alpha coefficient) was obtained for the sample in this present study as indices of scale reliability is 0.79.

### 9.2 The Effectiveness of the STEM Education Innovative Instructional Lesson Plan

To analyze the effectiveness of the innovative instructional lesson plans based on the model of learning management in a STEM Education Method of secondary students at the 10th grade level in physics classes with the processing and performance resulting effectiveness at 75/75 criteria. Table 1 reports of the effectiveness of the innovative instructional lesson plan.

**Table 1:** Score Total, Mean, Standard Deviation, Variance, Cronbach Alpha Reliability, F-test and Percentage for the Effectiveness Innovative Instructional Lesson Plans for the STEM Education Method

| Efficiency Type | Total Score | $\overline{X}$ | S.D. | Percentage |
|---|---|---|---|---|
| Efficiency Performance Processes ($E_1$) | 80 | 64.26 | 1.99 | 80.32 |
| Efficiency Performance Results ($E_2$) | 30 | 22.73 | 4.97 | 75.77 |
| The Lessoning Effectiveness (E1/E2) = 80.32/75.77 | | | | |

N = 72

In Table 1 shows the result for the effectiveness of the innovative instructional lesson plans based on the model of learning management in a STEM Education Method. Effectiveness of lessons during the learning process (E1) reveals of 80.32 and the performance effectiveness (E2) indicate that of 75.77, so the lessoning effectiveness (E1/E2) evidences of 80.32/75.77 over the threshold setting is 75/75.

### 9.3 Comparisons between Students' Learning Achievements of their Pretest and Posttest Assessments with the STEM Education Innovative Instructional Method

To compare between students' learning achievements of their pretest and posttest assessments with the innovative instructional lesson plans based on the model of learning management in a STEM Education Method of secondary students at the 10th grade level in physics classes with the 30-item *Leaning Achievement Test* (LAT) on Electric and Magnetic Issue was created by the researcher team of 30 optional items in 4 multiple choice options was assessed. Table 2 reports the statistically significance of the difference between students' learning outcomes of their pretest and posttest assessments. Using paired comparisons between different assessments of the same LAT as reports in Table 2.

**Table 2:** Total Score, Average Mean, Standard Deviation, Mean Difference, t-Value, and ANOVA (eta$^2$) Result for the LAT

| Assessing Test | Total score ( $\overline{X}$ =30) | Standard Deviation | Mean Diff. | *t*-Value | ANOVA (*eta*$^2$) |
|---|---|---|---|---|---|
| Pretest | 15.77 | 2.24 | 4.10 | 20.42*** | 0.68*** |
| Posttest | 19.87 | 3.26 | | | |

*N = 72, *ρ < 0.05, **ρ < 0.01, ***ρ < 0.001*

In Table 2, students' learning achievements, the district would need assessments at two points in time: before learning begins and at the end of the physics course. These assessments can be thought of as pre-tests and post-tests. The average mean scores of pretest of 15.77 and posttest revealed as 19.87. In most case, the standard deviation for the pretest as 2.24 and for the posttest as 3.26, and the mean difference between pre-tests and post-tests of 4.10 were compared. It also provides support the learning management in a STEM Education Method that teacher needed to take differences into consideration when planning and designing physics curriculum in the physics classes were assessed with the independent *t*-test and ANOVA (*eta*$^2$) significantly ($\rho < 0.001$).

**9.4 Students' Perceptions for the Creative Thinking Ability Test (CTAT)**

Table 3 reveals of students' perceptions of their creative thinking abilities with the 24-item *Creative Thinking Ability Test* **(**CTAT) in 4 scales, namely *Fluency Thinking* (the ability to produce great number of ideas or problem solutions in a short period of time); *Flexibility Thinking* (the ability to simultaneously propose a variety of approaches to a specific problem); *Originality Thinking* (the ability to produce new, original ideas); *Elaboration Thinking* (the ability to systematize and organize the details of an idea in a head and carry it out).

**Table 3:** Scale means' score, means, standard deviations, scale internal consistency (Cronbach Alpha Reliability), discriminant validity and F-test for the GCTQ

| Scale | Mean (30) | Average mean (5) | Standard deviation | Cronbach alpha reliability | Discriminant validity | *F*-test |
|---|---|---|---|---|---|---|
| Originality Thinking (OT) | 21.72 | 3.62 | 0.86 | 0.74 | 0.69 | 1.89* |
| Flexibility Thinking (FLT) | 23.70 | 3.95 | 0.81 | 0.75 | 0.68 | 2.09* |
| Fluency Thinking (FUT | 21.18 | 3.53 | 0.81 | 0.66 | 0.71 | 1.87* |
| Elaboration Thinking (ET) | 21.48 | 3.58 | 0.83 | 0.65 | 0.72 | 1.91* |
| Average Total | 22.02 | 3.67 | 9.36 | 0.85 | | 3.07** |

N = 72, *ϱ < 0.05, **ϱ < 0.01, ***ϱ < 0.001

The results given in Table 3 show the mean scores for each of the four CTAT scales. As each scale has six items ranging from 21.18 to 23.70 and average total score as 22.02. The average mean scores ranged from 43.53 to 3.95 and average total score as 3.67, respectively. Table 3 reports the internal consistency which ranged from 0.65 to 0.75 when using the actually scores. A successful evaluation of discriminant validity on each scale shows that a scale of the CTAT is correlated with other scales designed to measure theoretically the different three scales. Using an *F*-test is the test statistic has an F-distribution; it is most often used when comparing statistical models that have been fitted to a data set.

### 9.5 Associations between Students' Learning Achievements of their Posttest Assessment and their Creative Thinking Abilities with the Innovative STEM Education Instructional Method

Given the potential for students' learning achievements of their posttest assessment to their perceptions of their creative thinking abilities with the innovative instructional lesson plans based on the model of learning management in a STEM Education Method in physics, other student, teacher and classroom qualities were explored to determine their relationship with students' perceptions of their creative thinking abilities. Correlation's studies identified significant differences in students' learning achievements and their perceptions according to achievements made etc. In this study, it was also considered important to investigate associations that involved simple correlation and multiple regression analyses of relationships as a whole reported in Table 4.

**Table 4:** Associations between Students' Posttest Achievements for the LAT and their CTAT in Term of Simple Correlation (r), Multiple Correlations (R) and Standardized Regression Coefficient (β)

| Variables | Mean ($\overline{X}$) | S.D. | Simple Correlation (r) | Standardized Regression Validity (β) | Multiple Correlation (R) | Efficiency Predictive Value ($R^2$) |
|---|---|---|---|---|---|---|
| Posttest Assessment (LAT) | 19.87 | 3.26 | 0.39** | 0.48** | 0.7657** | 0.5864** |
| CTAT | | | | | | |
| OT | 3.62 | 2.80 | | | | |
| FLT | 3.59 | 2.70 | | | | |
| FUT | 3.52 | 2.95 | | | | |
| ET | 3.58 | 2.61 | | | | |

N = 72, *ϱ < 0.05, **ϱ < 0.01, ***ϱ < 0.001

Simple correlation and multiple regressions analyses were conducted to examine whether associations exists between students' learning achievements of their posttest assessment to their perceptions of their creative thinking abilities with the innovative instructional lesson plans based on the model of learning management in a STEM Education Method. Table 4 shows the correlations between posttest assessment (LAT) and towards physics. The CTAT creative thinking abilities among four scales were relative significantly, when using a simple correlation analysis (r) and standardized regression validity (β). The multiple correlations (R) was 0.7657 and the predictive efficiency ($R^2$= 0.5864) value indicated that 59% of the variances in students' creative thinking abilities to their physics classes were attributable to their post learning achievement in their physics laboratory classroom environments. It provides a measure of how well observed outcomes are replicated by the STEM education method, based on the proportion of total variation of students' learning outcomes explained by the STEM Education instructional model.

### 9.6 Associations between Students' Learning Achievements of their Posttest Assessment and their Science Related Attitudes with the Innovative STEM Education Instructional Method

Given the potential for students' learning achievements of their posttest assessment to their perceptions of their science related attitudes with the innovative instructional lesson plans based on the model of learning management in the STEM Education Method in physics, other student, teacher and classroom qualities were explored to determine their relationship with students' perceptions of their perceptions in physics laboratory environment classes. Correlation's studies identified significant differences in students' learning achievements and their perceptions according to achievements. In this study, it was also considered important to investigate associations that involved simple correlation and multiple regression analyses of relationships as a whole reported in Table 5.

The reports in Table 5, The multiple correlations (R) was 0.7152 and the predictive efficiency ($R^2$) value indicated that 51% of the variances in students' attitudes toward science to their physics classes were attributable to their post learning achievement in their physics laboratory classroom environments. The coefficient of determination denoted $R^2$ is a number that indicates the proportion of the variance in the dependent variable (LAT) that is predictable from the independent variable TOSRA. It provides a measure of how well observed outcomes are replicated by the STEM education method, based on the proportion of total variation of students' learning outcomes explained by the STEM Education instructional model.

**Table 5:** Associations between Students' Posttest Achievements for the LAT and their TOSRA in Term of Simple Correlation (r), Multiple Correlations (R) and Standardized Regression Coefficient (β)

| Variables | Mean ($\overline{X}$) | S.D. | Simple Correlation (r) | Standardized Regression Validity (β) | Multiple Correlation (R) | Efficiency Predictive Value ($R^2$) |
|---|---|---|---|---|---|---|
| Posttest Assessment (LAT) | 19.87 | 3.26 | 0.36** | 0.34** | 0.7152** | 0.5116** |
| TOSRA | 3.58 | 4.10 | | | | |

N = 72, *ϱ < 0.05, **ϱ < 0.01, ***ϱ < 0.001

## 10. Conclusions

The monitoring and evaluation students' learning achievements through their learning activities with the STEM education instructional method for developing their creative thinking abilities and their attitudes toward science of secondary students at the 11$^{th}$ grade level in physics classes were assessed students' learning outcomes to investigate and examine of the effects of the activity-based on learning approaching management through the STEM education instructional method for improving the creative thinking abilities, learning achievements, and environmental perceptions in physics classes of students at the 10$^{th}$ grade level for the target group of 72 upper secondary students who sat at the 10$^{th}$ grade level in two physics classes in the second semester of academic year 2016 at Borabu Wittyakhan School under the Secondary Educational Service Area Office 26, Ministry of Education in Thailand. The context of the content that it composes of the Electric and Magnetics Issue from the Strand 4: Forces and Motion that focused on the Standard SC4.2 from the Basic Education Core Curriculum B.E. 2551 (A.D.2008) was aimed at the full development of learners in all respects - morality, wisdom, happiness, and potentiality for further education was selected of the context of the strand and learning standard in science learning area in terms of students' perceptions of their learning environment and their creative thinking ability toward physics were designed.
In this design, which uses two groups, one group is given the treatment and the results are gathered at the end. The student group receives no treatment, over the same period of time, but undergoes exactly the same tests. Statistical analysis can then determine if the intervention had a significant effect. The result for the effectiveness of the innovative instructional lesson plans based on the model of learning management in a STEM Education Method was designed. Effectiveness of lessons during the learning process (E1) reveals of 78.23 and the performance effectiveness (E2) indicate that of 75.38, so the lessoning effectiveness (E1/E2) evidences of 78.23/75.38 over the threshold setting is 75/75.

Validities of the STEM education innovative instructional lesson plan was created learning plan offers the counselor to verify the content validity for students' learning activities, teaching materials, and evaluation in the learning management plan was corrected as suggested by the advisors and the 3-professional expert educators with the were reviewed and assessed the validity of content, purpose learning with the IOC value (*Index of Item Objective Congruence*), the acceptable accuracy must be 4.47 or higher. It appears that the research plan developed by the researcher has an average of 3.51 to 5.00, which is moderate to the highest. The 30-item *Leaning Achievement Test*

(LAT) on Electric and Magnetic Issue was created by the researcher team of 30 optional items in 4 multiple choice options was assessed in the second step of research methodology. The LAT was used to analyze the difficulty, the discriminative value of the achievement test using the criterion-selection criteria was 0.80 – 1.00 and the discriminative value ranged from 0.22 to 0.69. The 24-item *Critical Thinking Ability Test* (CTAT) CTAT was indicated that of the difficulty (p) ranged from 0.21 to 0.79, with the discriminative value (r) between 0.34-0.65 and the internal consistency (Cronbach rerilabiliy) was 0.85. The *Test of Science-Related Attitudes* (TOSRA) questionnaire was selected to use with the aim of investigating any possible relationships with the instructional management between STEM education methods, The internal consistency (Cronbach alpha coefficient) was obtained for the sample in this present study as indices of scale reliability is 0.79.

The results for the effectiveness of the innovative instructional lesson plans based on the model of learning management in a STEM Education Method were found. Effectiveness of lessons during the learning process (E1) reveals of 80.32 and the performance effectiveness (E2) indicate that of 75.77, so the lessoning effectiveness (E1/E2) evidences of 80.32/75.77 over the threshold setting is 75/75. Statistically significance of the difference between students' learning achievements of their pretest and posttest assessments with the innovative instructional lesson plans based on the model of learning management in a STEM Education Method were assessed with the independent *t*-test and ANOVA ($eta^2$) significantly ($\rho < 0.001$).

Associations between students' learning achievements of their posttest assessment and their creative thinking abilities with the innovative STEM education instructional method were assessed. The CTAT creative thinking abilities among four scales were relative significantly, when using a simple correlation analysis (r) and standardized regression validity (β). The multiple correlations (R) was 0.7657 and the predictive efficiency ($R^2$= 0.5864) value indicated that 59% of the variances in students' creative thinking abilities to their physics classes were attributable to their post learning achievement in their physics laboratory classroom environments.

Associations between students' learning achievements of their posttest assessment and their science related attitudes with the innovative STEM education instructional method were related. The multiple correlations (R) was 0.7152 and the predictive efficiency ($R^2$) value indicated that 51% of the variances in students' attitudes toward science to their physics classes were attributable to their post learning achievement in their physics laboratory classroom environments. The coefficient of determination denoted $R^2$ is a number that indicates the proportion of the variance in the dependent variable (LAT) that is predictable from the independent variable TOSRA. It provides a measure of how well observed outcomes are replicated by the STEM education method, based on the proportion of total variation of students' learning outcomes explained by the STEM Education instructional model.

## 11. Discussion

The results of this research study focused on the monitoring and evaluation students' learning achievements through their learning activities with the STEM education instructional method for developing their creative thinking abilities and their attitudes toward science of secondary students at the $11^{th}$ grade level in physics classes have probably got some ideas of how experiments should be run. Why don't researchers just look at something, poke it with a stick, and then study the changes? Researchers are always making things super complicated. The reason ran a pretest-posttest experiment is to see if your manipulation, the thing that to be able to looking at, has caused a change in the participants. Since student is being manipulated in the same way, any changes and see across the group of participants is likely from the manipulation. This means teachers test them before doing the experiment, then teachers run their experimental manipulation, and then teachers test them again to see if there are any changes. So how does this really work? This is the research designed for assessing students' assessments of their pretest and posttest techniques were compared.

Focused on the PLEI, the results of the present study were compared with those of previous studies conducted in Australia, the USA, Canada, England, Israel and Nigeria. It was found that the physics laboratory classes reflected lower levels of Integration and Material Environment, and higher levels of Rule Clarity, than Australian, American, Canadian and Israeli science classes. However, the level of Open-Endedness in laboratory class is relatively lower than that of the Australian, American and Canadian science classes. In the area of differences, there were differences in perceptions of science laboratory classroom environments for both the sample as well as for the samples from the other countries. Associations between students' perceptions of the nature of the science laboratory classroom environment and their learning achievements and their creative thinking ability outcomes also existed for all samples in all the countries concerned, including Thailand.

As researchers strive to better prepare students for real world careers and challenges, we need to focus on developing students' creative thinking skills. Educators can encourage students to become 21st-century problem solvers by introducing them to a wide variety of thinking tools. Affording students the opportunity to flex their creative problem solving skills offers them the chance to practice skills that are highly prized in real-world situations. Entering college or the workforce with well-developed creative thinking skills proves a great advantage for today's new grads. In education, we routinely teach students how to use various sets of cognitive tools to make academic work easier, more efficient, or more productive: for example, research methods, note-taking strategies, or ways to remember and organize information. In teaching thinking, we need to give students cognitive tools and teach them to use these tools systematically to solve real-life problems and to manage change. These tools apply to two essential categories: creative thinking abilities. Suggestions that the effects of the activity-based on learning approaching management through the STEM education instructional method for fostering the creative thinking abilities, learning achievements, and environmental perceptions in physics laboratory classes of students at the $10^{th}$ grade level that should be needed to know how to implement authentic STEM teaching and learning into classrooms are following as the $21^{st}$ century, responsibility.

One of the newer educational terms that we see frequently in the news is STEM education. But what exactly is STEM education and is it appropriate for preschoolers? STEM is an acronym for science, technology, engineering, and math. STEM Education, a term initiated by *the National Science Foundation*, refers to an educational approach which integrates more than one of these disciplines. Science, technology, engineering, and math may seem like lofty subject matter for preschool students. In reality, preschoolers spontaneously engage in STEM activities indoors and out on a regular basis. With a little guidance from us, we can enhance students' opportunities to engage in STEM learning and develop their creative thinking abilities and their attitudes toward science skills. While building with blocks, students can build bridges and ramps, incorporating engineering and math. They can add a technology component by researching these on the computer. Outdoors, students could help solve the problem of getting water to a garden they helped to plant, drawing on their science and engineering knowledge. Incorporating the use of students garden tools like rakes, shovels, and a wheelbarrow build on this activity to provide an even broader STEM experience.

Focused on the results of the *Creative Thinking Ability* were assessed students' perceptions. It's helpful to be able to come into a creative situation and demonstrate willingness to champion another person's idea. It can open the way to getting others to support your thinking, as well. When it comes to own ideas, it's easy to be a hypocrite and apply all kinds of hurdles to other ideas while letting own thinking slide by unchallenged in your own mind. Just one thing to remember: don't become somebody known for doing this! Often (maybe "almost always") compromising on creative ideas leads to something nobody likes, recognizes, or thinks satisfies the original objective. Being able to dissect ideas to pull out highlights and put them together as something new, however, is entirely different, and a great skill to have. This skill really tests whether students believe so strongly in an idea they're willing to let someone else step up and take it on as their own idea to see it prevail. The key to seeing students' idea win out can be letting somebody else be the vocal proponent for it. It's tempting to jump in right away and make all the points their feel necessary in a creative discussion before anyone else talks. At times though, patience and silence are called for when it becomes clear someone can and will express your perspective – and can do it more appropriately than you can. There are many creative ideas which, while being really cool, have nothing to do with what you're trying to achieve and how they should be achieving it. When confronted with others who are passionately arguing for highly creative yet hardly strategic concepts, make and remake your case if the idea they're advocating is on the mark strategically. Not only do students want to make them stronger creatively at every juncture, it's in your best interests to help improve the creative performance of their overall team. Creative meetings are a great opportunity to spot gaps others labor under as well as seeing their own creative shortcomings. Inventory what students saw (or didn't see) after a creative meeting and get to work filling the gaps with the STEM education instructional method are provided.

In this research study, in terms of the science related attitudes, the methods and skills used by scientists are intimately connected to a set of attitudes common in the practice of science. A scientific attitude is a disposition to act in a certain way or a demonstration of feelings and/or thoughts. Studies of the actions of scientists have led to lists of scientific attitudes such as displayed below. Some attitudes such as honesty would be expected in any human Endeavour, but other attitudes such as tolerance of uncertainty are more characteristic of scientists. Because of attitudes are mental predispositions toward people, objects, subjects, events, and so on. In science, attitudes are important because of three primary factors. Student's attitudes often are more emotional than intellectual. Curiosity, the natural start of it all, may be accompanied by perseverance, a positive approach to failure (or acceptance of not getting one's own way all the time), and openness to new experiences and even other people's points of view (tolerance for other children's ways of playing a favorite game). These are fundamental attitudes that are useful for building specific scientific attitudes that are necessary for success and the continuation of the science cycle.

Finally, monitoring is the systematic and routine collection of information from projects and STEM education method for four main purposes: To learn from experiences to improve practices and activities in the future; To have internal and external accountability of the resources used and the results obtained; To take informed decisions on the future of the initiative; and To promote empowerment of beneficiaries of the initiative. Evaluation is assessing, as systematically and objectively as possible, a completed project or STEM education method (or a phase of an ongoing project or STEM education method that has been completed). Evaluations appraise data and information that inform strategic decisions, thus improving the project or STEM education method in the future. Evaluations should help to draw conclusions about five main aspects of the intervention: relevance, effectiveness, efficiency, impact, and sustainability for developing their creative thinking abilities and their attitudes toward science of secondary students at the K-12 grade level in classroom learning environment inventories are provided.

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